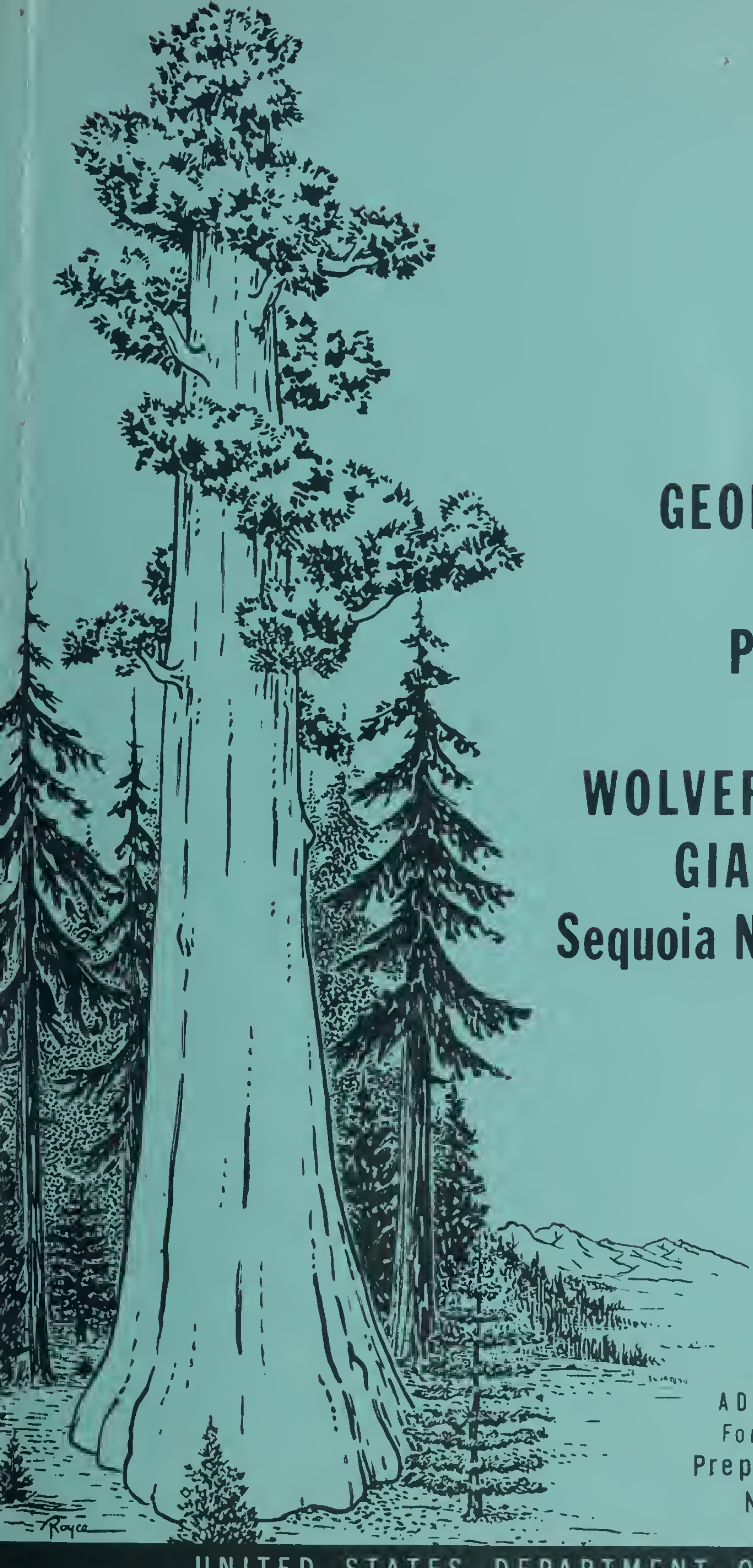

GEOPHYSICAL SURVEY and PUMPING TEST in WOLVERTON CREEK VALLEY GIANT FOREST AREA Sequoia National Park, California

ADMINISTRATIVE REPORT
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Prepared in cooperation with
NATIONAL PARK SERVICE

UNITED STATES DEPARTMENT OF THE INTERIOR
Geological Survey
WATER RESOURCES DIVISION

MENLO PARK, CALIFORNIA
1969

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Water Resources Division

GEOPHYSICAL SURVEY AND PUMPING TEST IN WOLVERTON CREEK VALLEY, GIANT FOREST AREA SEQUOIA NATIONAL PARK, CALIFORNIA

By

Gilbert L. Bertoldi and G. A. Miller

Prepared in cooperation with the
National Park Service
Department of the Interior

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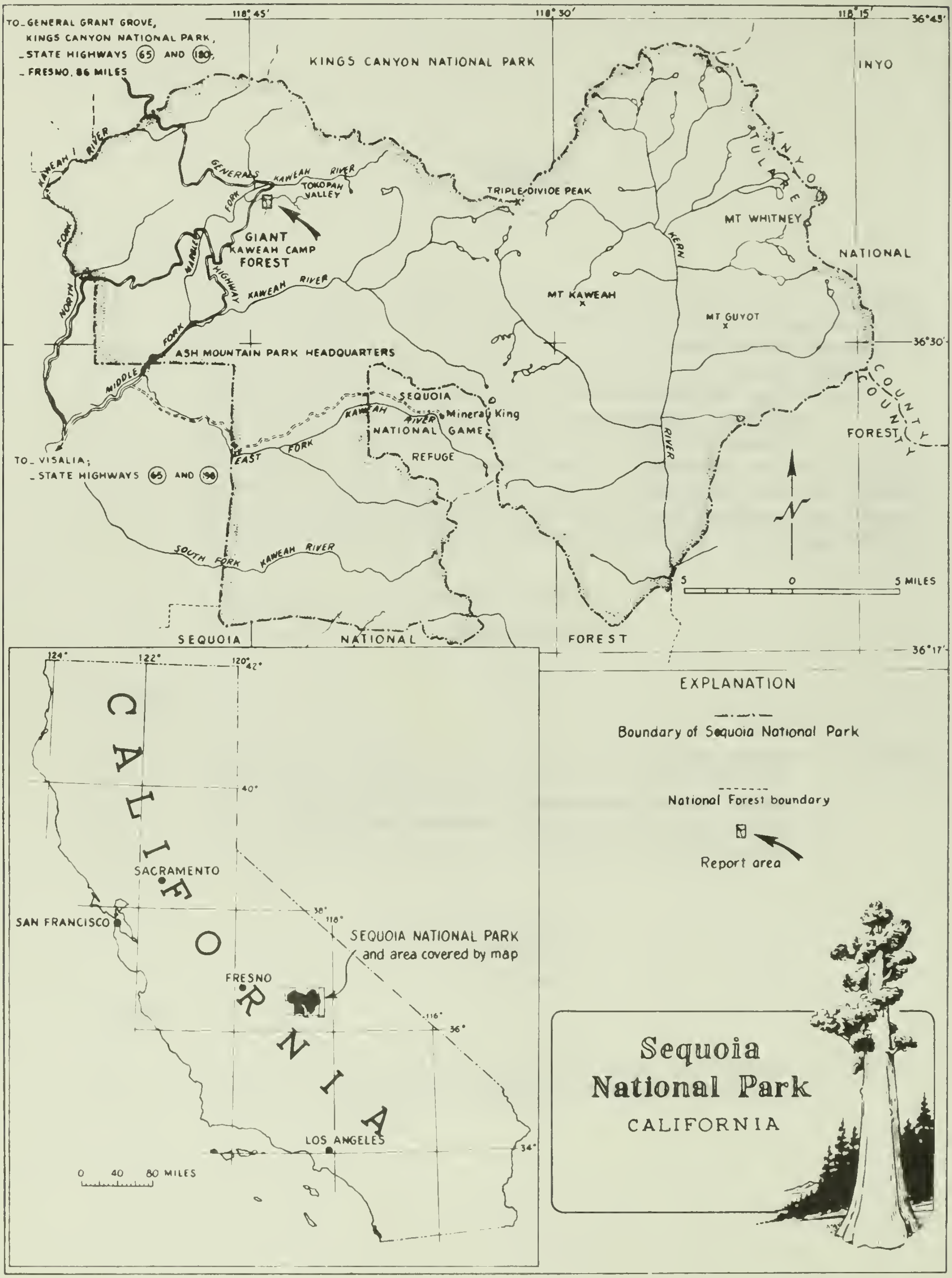

FIGURE 1._ Index map

GEOPHYSICAL SURVEY AND PUMPING TEST IN WOLVERTON CREEK VALLEY, GIANT FOREST AREA, SEQUOIA NATIONAL PARK, CALIFORNIA

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ABSTRACT

Estimates of hydrologic properties, and quantities of saturated alluvium based upon a geophysical survey in Wolverton Creek Valley, indicate that a part of the saturated alluvium (3,000 acre-feet) contains about 450 acre-feet of water in storage. Depth to bedrock, estimated at 11 points in a seismic survey, ranged from 40 to 150 feet below land surface. Data from pumping tests indicate that the specific capacity of an existing well in the valley has decreased considerably since 1967. However, properly designed wells should sustain adequate yields.

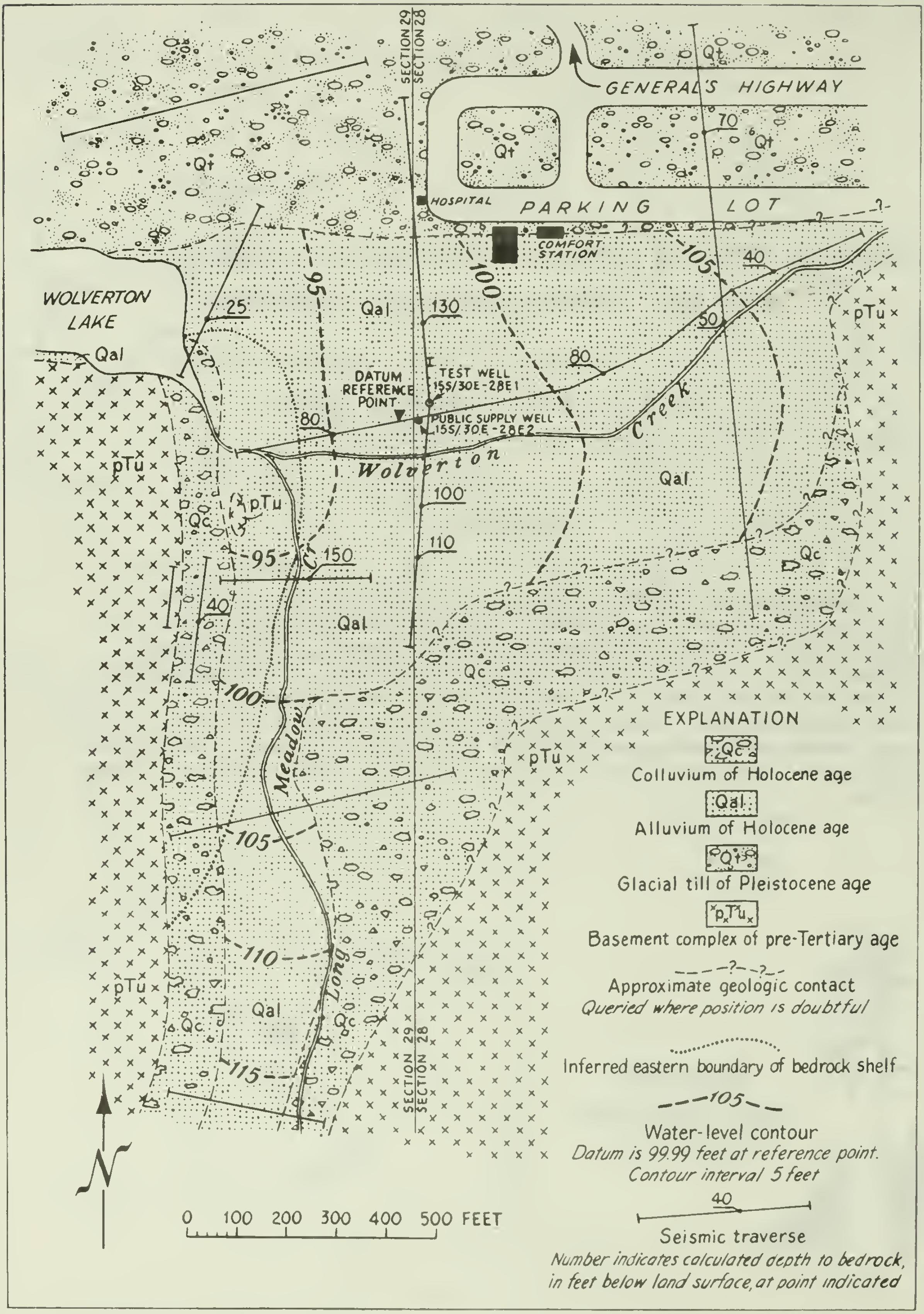
SECTION 29
SECTION 28
GENERAL'S HIGHWAY
Qt
70
HOSPITAL
PARKING LOT
COMFORT STATION
105
40
WOLVERTON LAKE
25
95
Qal
130
100
pTu
50
80
TEST WELL 15S/30E-28BE1
DATUM REFERENCE POINT
PUBLIC SUPPLY WELL 15S/30E-28E2
Wolverton Creek
Qc
150
110
Meadow Cr.
Long
115
EXPLANATION
Qc
Colluvium of Holocene age
Qal
Alluvium of Holocene age
Qt
Glacial till of Pleistocene age
pTu
Basement complex of pre-Tertiary age
Approximate geologic contact
Queried where position is doubtful
Inferred eastern boundary of bedrock shelf
105
Water-level contour
Datum is 99.99 feet at reference point.
Contour interval 5 feet
40
Seismic traverse
Number indicates calculated depth to bedrock, in feet below land surface, at point indicated
N
0 100 200 300 400 500 FEET

FIGURE 2.—Geologic map showing location of wells, seismic data, and water-level contours.

INTRODUCTION

In September and October 1968, in cooperation with the National Park Service, the U.S. Geological Survey investigated part of Wolverton Creek Valley near the Giant Forest area of Sequoia National Park (fig. 1). The purpose of the study was to evaluate the alluvium in the area as a source of water, in greater detail than Croft (1966) who suggested the site for the existing wells (fig. 2). At present, water is supplied to the Giant Forest area from two intakes in Wolverton Creek about 0.7 mile upstream from the public-supply well (15S/30E-28E2). The Park Service requested the evaluation because during late summer when the flow in the creek decreases, the supply is marginal. The present average daily water requirement for the Giant Forest area is 40,000 gpd (gallons per day), the future peak demand has been estimated to be 300,000 gpd. Peak demand historically occurs for a few days during the Labor Day weekend; during the remainder of the year considerably less water will be needed. The scope of this report includes: (1) A description of the configuration of the basin, (2) an estimate of the quantity of ground water in storage, and (3) an evaluation of test pumping.

Mr. Jerry Eubanks, Chief Maintenance Engineer, Mr. Lawrence Brochinni, Supervisory Maintenance Engineer, and Mr. Paul Turner, Chief Ranger, Kaweah District, Sequoia National Park, provided assistance, information, and equipment during the field investigation. This report was prepared by the U.S. Geological Survey, Water Resources Division, under the general supervision of R. Stanley Lord, district chief for California, and under the immediate direction of Willard W. Dean, chief of the Sacramento subdistrict office.

THE GROUND-WATER BASIN

Areal Extent

The ground-water basin of Wolverton Creek Valley (fig. 2) consists of alluvium of Holocene age bounded on the north by glacial till of Pleistocene age, on the east and west by basement complex of pre-Tertiary age. The southern edge of the basin is not closed within the study area but is constricted to a width of about 350 feet.

The basement complex of pre-Tertiary age consists of dense impermeable granodiorite, and is considered non-water-bearing, although water may occur in fracture systems within the unit. The glacial till of Pleistocene age consists of poorly sorted sand, silt, clay, and angular boulders of granodiorite. The alluvium of Holocene age consists of heterogeneous deposits mainly medium to coarse sand with minor amounts of clay and silt. Colluvium of Holocene age consists mainly of coarse sand containing some granule and pebble size, angular, fragments of dioritic rock probably derived from adjacent outcrops of massive rocks of the basement complex.

Subsurface Configuration

The subsurface configuration of the ground-water basin was determined by geophysical surveys--magnetic and seismic.

Magnetic survey.--A reconnaissance magnetic survey of the area was made using a flux-gate magnetometer. Figure 3 presents the results of the survey. The location, length, and direction of each traverse is shown as a straight line. Each profile (representing magnetic variation along the traverse) is plotted above its respective traverse. The profiles are indicators of the surface configuration of bedrock only if the magnetic properties of underlying materials do not change along the traverse. They do not represent the actual surface, but do establish supplementary data valuable in obtaining and interpreting data from the more precise seismic survey.

Analysis of the magnetometer data suggests the presence of a shallow shelf of bedrock beneath unconsolidated deposits along the northern part of the west wall of Long Meadow Creek canyon (figs. 2 and 3). Seismic-refraction data (fig. 2) and an outcrop of bedrock confirm the presence of the shelf. In general, magnetometer readings on bedrock along the west side of Long Meadow Creek are several hundred gammas higher than readings on bedrock along the east side. The reason for the higher readings was not apparent from field examination of bedrock outcrops.

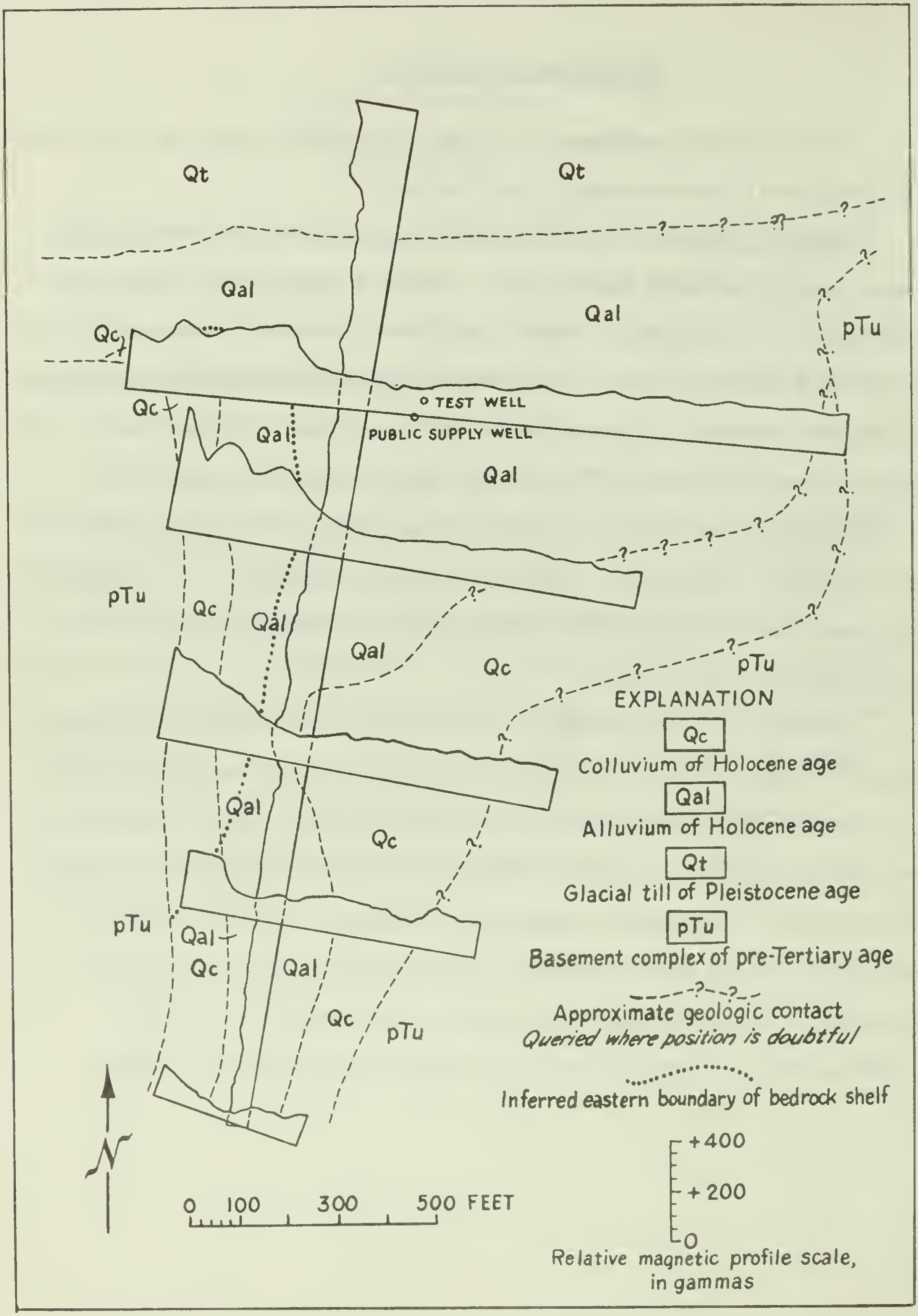
Qt
Qt
Qal
Qal
pTu
Qc
Qc
O TEST WELL
PUBLIC SUPPLY WELL
Qal
Qal
pTu
Qc
Qal
Qal
Qc
pTu
Qal
Qc
pTu
Qal
Qc
Qal
Qc
pTu
EXPLANATION
Qc
Colluvium of Holocene age
Qal
Alluvium of Holocene age
Qt
Glacial till of Pleistocene age
pTu
Basement complex of pre-Tertiary age
Approximate geologic contact
Queried where position is doubtful
Inferred eastern boundary of bedrock shelf
0
100
300
500 FEET
+400
+200
0
Relative magnetic profile scale, in gammas
N

FIGURE 3. — Magnetometer traverses and magnetic profiles.

Seismic survey.--A seismic survey was made using a 12-channel refraction seismograph. The energy source was dynamite placed in shallow shotholes and stemmed with water or wet sand. Most of the shotholes were dug to the water table. Geophone, water table, and shot-point elevations were referenced to an assumed elevation of 99.99 feet at the datum reference point (fig. 2). Vertical and horizontal control for most of the seismic lines is accurate to the nearest foot. One short traverse (about 100 feet northeast of the datum reference point near the test wells) was used as an equipment check. The equipment-check seismogram showed what appeared to be reflections, probably from bedrock at a depth of less than 160 feet. Except for the equipment check, refraction traverses were used throughout the area. Depth to bedrock was determined from refraction velocities within materials tested in the area. Table 1 summarizes these velocities.

Table 1.--Refraction velocities

(in feet per second)

Material	Range	Most consistent value
Loose, dry sand	1,000 - 2,000	---
Saturated alluvium	4,500 - 5,200	a4,600
Saturated glacial till	6,000 - 8,000	7,000
Bedrock	10,000 - 20,000	15,000

a. This unusually low velocity for saturated alluvium is due in part to the low temperature of the material (less than 10°C).

Analysis of the seismograms from the refraction traverses suggests that the configuration of the bedrock surface beneath the unconsolidated material is irregular and nowhere level over a large area. Precise and consistent information about depth to bedrock was difficult to obtain from seismograms of the traverses shown without numbers (fig. 2). However, fairly reliable depths to bedrock based upon a velocity interface were obtained at 11 locations on the traverses (fig. 2). The velocity interface may represent bedrock or the top of indurated glacial till; however, in either case the high seismic velocity encountered below suggests that the interface is the base of the aquifer.

The canyon of Long Meadow Creek was deeply scoured by glaciers and is partly filled by alluvium and till. The axis of the bedrock valley trends north-northeast.

GROUND WATER IN STORAGE

Ground water in storage was computed as the product of the volume of saturated alluvium and estimated average specific yield.

Several assumptions were made in computing the volume of the aquifer, most of which should tend to result in a conservative estimate. For example, saturated alluvium probably underlies much of the area covered by colluvium (fig. 2), but this part of the aquifer was not included in the estimate. Because of a lack of refraction data none of the glacial till north of Wolverton Creek was included as part of the aquifer, although a large volume of the till probably is saturated (some shotholes intercepted saturated till). The canyon of Long Meadow Creek, south of about the 100-foot water-level contour (fig. 2), was assumed to be underlain by a 50-foot thickness of aquifer material. The alluvium in this part of the canyon was too deep in relation to its width to use refraction seismic techniques to estimate depth to bedrock. The aquifer overlying the buried shelf of bedrock in the northwestern part of the area was assumed to be 20 feet thick over the shelf. This is less than half the thickness determined from two seismic traverses over the shelf.

The volume of the aquifer was computed by constructing polygons about the points of estimated depth to bedrock, measuring the surface area of the polygons, and computing the volume by assuming a level bottom and an average water-table elevation for the top of the solid figure. The total surface area of the aquifer, equal to the surface area of the polygons, is about 45 acres. The total calculated volume (of saturated alluvium) is about 3,000 acre-feet, and the average saturated thickness is about 70 feet. Possibly half again the volume occurs in the sediment not included in the calculation.

Davis and others (1959, p. 203) estimated the specific yield of sand, similar to the alluvium in Wolverton Creek Valley, at 25 percent. An estimated specific yield of 15 percent, used here, makes an allowance for the fine-grained part of the alluvial section.

The product of the estimated specific yield and volume of saturated alluvium approximates 450 acre-feet, barely enough to satisfy the estimated peak demand if the peak demand occurred daily all year long. The maximum daily demand for water probably will occur during the Labor Day weekend; average daily demand will be less at any other time during the year, probably tapering to negligible amounts during the winter months. Based on an oral communication from Mr. Gerard S. Witucki, Supervisory Hydrologist of the National Park Service, about projected water demand in a nearby area, the annual average daily water requirement is about one-third of the peak. Applied to the Wolverton Creek area, the total annual water requirement is less than 115 acre feet. As yield of the aquifer can be conservatively estimated at 225 acre-feet, one-half of the calculated yield, the quantity of ground water available in Wolverton Creek Valley should be adequate to supply the projected needs of the area. Considering heavy annual precipitation and seasonal use of wells, annual recharge to the aquifer probably will be sufficient to replace extracted water.

RESULTS OF TEST PUMPING

The public-supply well and test well had filled in 3 feet, the test well, 27 feet, since being drilled in August 1967. Each well was cleaned and developed by airlifting water and surging.

A step-drawdown test was made by pumping the public-supply well at constant discharge and recording drawdown for a given period of time (15 minutes), then repeating the process for each progressively larger constant discharge. Results of the test (fig. 4) indicate the well will yield about 100 gpm (gallons per minute) with 89 feet of drawdown; however, a suggested continuous pumping rate is 70-80 gpm. Decreases in specific capacity of the well (gallons per minute per foot of drawdown) between the 1967 and 1968 tests (fig. 4) are probably due to clogging of the gravel pack surrounding the inner casing of the well. The nature of alluvium in the valley is such that large quantities of sand can be expected to enter any well. The construction of the public-supply well (Croft, 1966, p. 44) is especially susceptible to clogging since any sediment-bearing water entering the gravel-packed space between the inner and outer casing must travel downward through the gravel pack to enter the screen near the bottom of the casing. Pumping probably has induced fine sediment to bridge pore spaces in the gravel pack, causing a lowered permeability, within the gravel pack, and the decrease in capacity. Future pumping may further reduce the yield. Reversing the flow of water in the gravel pack or surging to break the bridging cannot be done by conventional methods because the inner casing is not perforated throughout the water-bearing section. Further, access to the gravel pack from the top is prevented by a 5-foot concrete plug. If future wells in this area are to be pumped at maximum capacity, careful well design will be required both to assure initial high yields and to maintain those yields.

1967 TEST		1968 TEST	
Discharge (gpm)	Specific capacity (gpm/ft)	Discharge (gpm)	Specific capacity (gpm/ft)
10	6.7	50	1.4
20	3.6	60	1.2
30	3.3	70	1.2
40	3.0	80	1.2
50	2.6	90	1.1
60	2.5	100	1.2

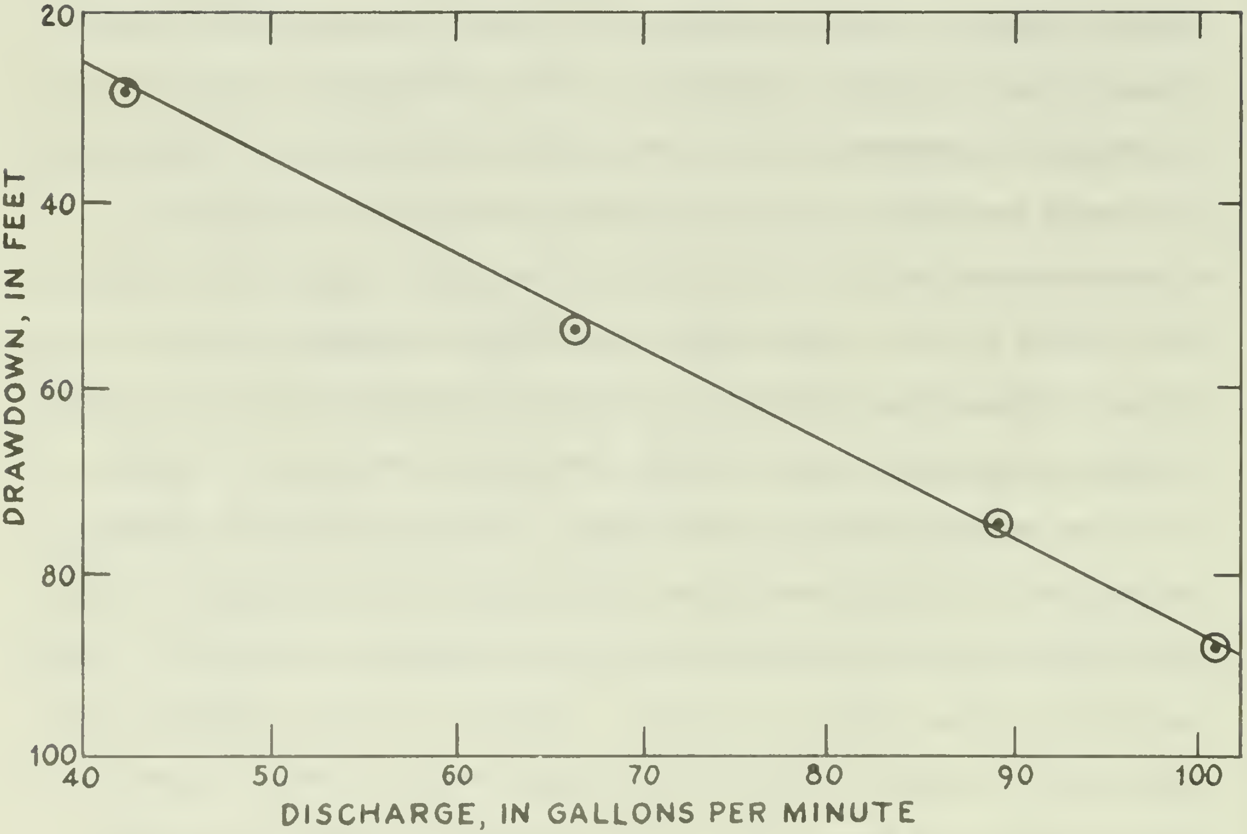

FIGURE 4.— Graph showing discharge-drawdown relation and specific capacities for public-supply well 15S/30E-28E2.

An 8-hour aquifer test was made, but the apparent complexity of the aquifer system and mechanical problems with the pump made the results inconclusive. Drawdown was measured in the test well while the public-supply well was pumped. Drawdown data from 1967 (Croft, 1966, p. A6) were compared to 1968 data, but no uniform relation could be established. Interference between wells is almost certain to occur, but considering the heterogeneity of the subsurface materials described in the driller's logs of the two wells, and the results of testing, interference effects could not be determined.

In conjunction with the test pumping, recorders were installed on Wolverton Creek to observe the effect of pumping on flow in the creek. Records indicate the test pumping had no effect on flow in the creek.

Also in conjunction with test pumping and after 8 hours of continuous pumping a sample of water was taken. Chemical composition of the sample (table 2) indicates that water from the public-supply well is of excellent chemical quality. Comparison with an analysis made in August 1967 shows no appreciable change in quality.

Table 2.--Chemical analysis of water

(Analysis by U.S. Geological Survey)

Well number	15/30-28E2
Date of collection	10/4/68
Laboratory number	57938
Water temperature	7.4°C
Percent sodium	30
Specific conductance (micromhos at 25°C)	107
pH	7.2

Concentrations in milligrams per liter

Silica (SiO_2)	30
Iron (Fe)	.1
Calcium	12
Magnesium (Mg)	1.5
Sodium (Na)	7.5
Potassium (K)	1.6
Bicarbonare (HCO_3)	66
Carbonate (CO_3)	0
Sulfate (SO_4)	1.0
Chloride (Cl)	.6
Fluoride (F)	0
Nitrate (NO_3)	1.5
Boron (B)	0
Dissolved solids (calculated	89
Hardness as $CaCO_3$	36
Noncarbonate hardness as $CaCO_3$	0

SUMMARY AND SUGGESTIONS

The estimated quantity of water in storage is adequate to satisfy projected water needs, and chemical quality meets the standards for drinking water (U.S. Public Health Service, 1962).

Results of test pumping in August 1967 and September 1968 show that the specific capacity of the public-supply well has decreased. The decrease is probably related to the heterogeneity of the aquifer and to the well design. Screening to restrict inflow of fine-grained material, proper gravel sizing to provide screen protection, and control of ground-water velocity at the borehole interface may be necessary to ensure continued adequate yield from wells in this aquifer. For these reasons the services of a professional well-design engineer will probably be required when new wells are drilled.

In addition to design, the number and spacing of wells drilled in the area, the withdrawal rates from such wells, and the quantity and rate of recharge to the aquifer will affect the total sustained yield for the area. Figure 5 shows suggested well sites and well spacing.

Although the chemical quality of the well water is better than the minimum suggested standards for drinking water (U.S. Public Health Service, 1962), contamination by effluent from the comfort station south of the parking lot and upgradient from the public-supply well could occur. Therefore, a chemical-quality monitoring program is suggested. Constituents that will indicate pollution are nitrate and chloride; future determinations might include ammonia nitrogen (both NH_3 and NH_4^{+1}), phosphorus, and coliform bacteria. A continuing program to monitor these constituents should provide an adequate pollution-detection program.

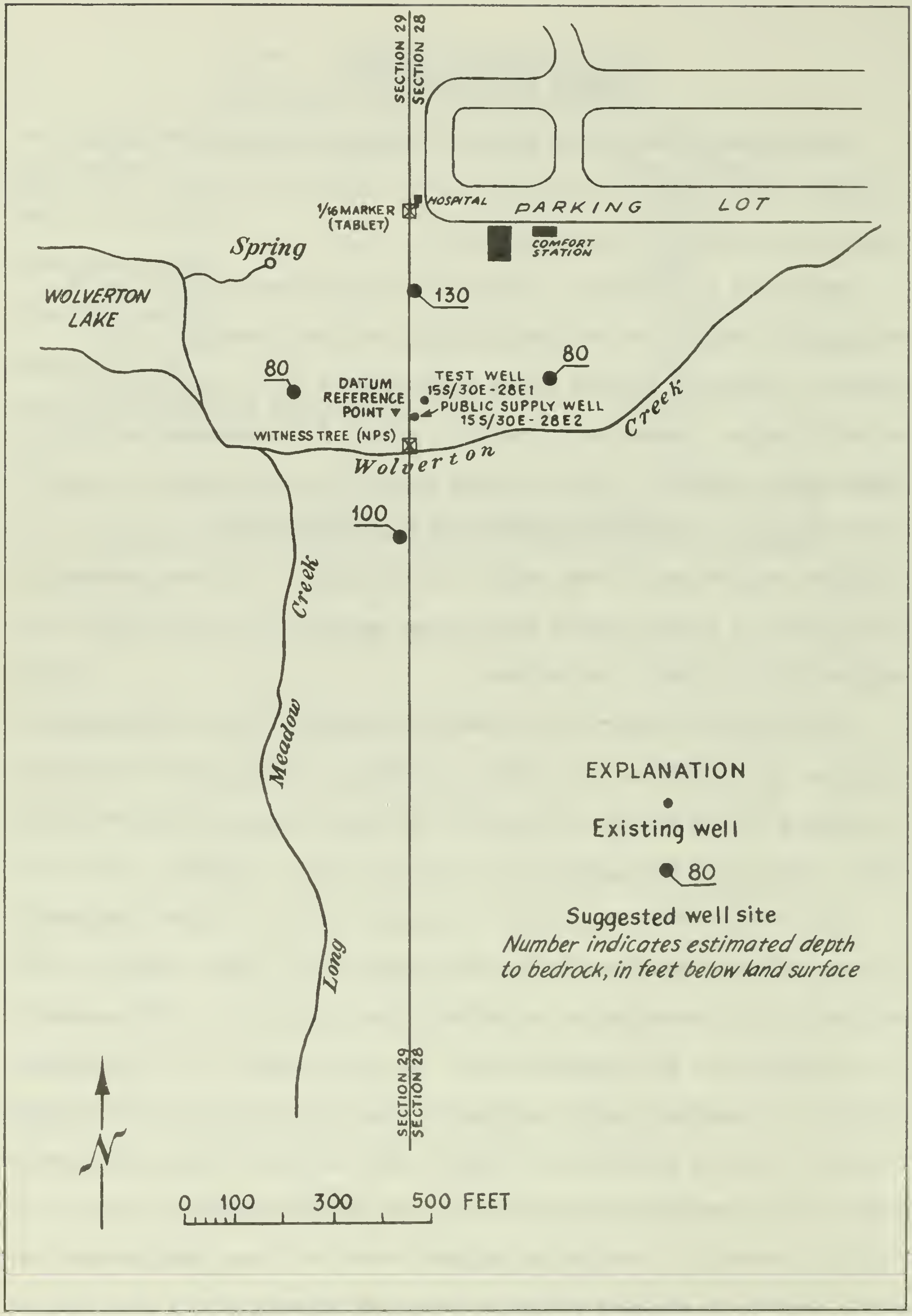

FIGURE 5.— Suggested well sites.

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U.S. Public Health Service, 1962, Drinking water standards: U.S. Dept. Health, Education, and Welfare, Public Health Service Pub. no. 956, 61 p.

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